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CROSSING EXPERIMENTS WITH TRITICALE

Der Zuechter (Genetics and Breeding Research), Vol 36, No 6, 1966, pp 249-255.

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Summary [Author's English summary]

Besides crosses between wheat and rye, crossability between hexaploid and octoploid Triticale was tested. F_1 hybrids as well as subsequent generations were examined.

Octoploid Triticale F_1 showed no higher seed productivity than did the better parent. Even in subsequent generations an attempt to select suitable types for practical cultivation failed.

Though hexaploid and octoploid F_1 plants produced considerably less seed than both parents, we succeeded in selecting valuable hexaploid individuals from subsequent generations. While for the past 14 years we were unable to improve our hexaploid Triticale No. 1 produced in 1952, hexaploid Triticale No. 30 produced from crossing Triticale of different degrees of polyploidy appears to be important for practical breeding. In this Triticale we succeeded in fixing the red color of the auricola characteristic of hexaploid wheat F 481.

In 1964 we started growth experiments on a larger scale. The first sowing was made on an area of 2.6 ha in sandy soil on the cooperative farm Aranykalasz in Kecskemet (grain yield: 21.1 quintals/ha). -- Tetra rye and winter rye gave lower yield under similar conditions.

*I tkank Professor Barna Gyorffy for setting the problem and numerous advices, and my assistants for their conscientious work in the breeding tests and the execution of the experiments.

In 1965 Triticale No. 30 was tested on an area of about 17 ha on the same farm* and in our institute on an area of about 3 ha**. In the autumn of 1965, this secondary hexaploid Triticale was sown over about 170 ha.

Introduction

Wheat-rye crossings have deservedly been given a great deal of attention among plant breeders and geneticists. The fact that the genom stock of two species may be combined in a new species or in a third species, led to the thought that the hybrid constitution of the constant wheat-rye hybrid is richer and more variable, and thus the genetic value of the new species is higher. On the basis of theoretical considerations, Triticale possesses a larger and more manifold variation breadth than wheat or rye, since it combined the genoms of both the wheat and of the rye.

However, the above-mentioned theoretical considerations could not be justified by the results obtained in this country and abroad (Hagberg and Akerberg 1962; Leiser 1954; Muentzig 1963; Nakajima 1963; Pissarev 1959; Schneider 1955; Vettel 1958, 1959).

Several breeders succeeded in obtaining relatively large numbers of hybrids from easily crossable wheat and rye types.

Up to now, we know of not a single Triticale produced that has surpassed wheat and rye in its properties (Aufhammer et al. 1961; Kappus 1964; Kiss 1958; Krolow 1963; Meyer 1965; Pissarev 1959; Sanchez-Monge 1956, 1958; Schneider 1955; Vettel 1960a, b).

In the course of time, the unfavorable characteristics of low fertility, low seed yield, shrunken seed type, etc., of the Triticale produced to date were indicated from the biological standpoint also. The salient features of this standpoint can be summarized as follows:

(1) Under natural conditions, no fertile transition hybrids developed in spite of wheat and rye having lived in close vicinity to each other for millenia. The incompatibility between the two species was too pronounced.

(2) A harmonic joining of the two plants, in which the offspring was not disturbed by either of the parents, appears to be impossible. One of the most convincing proofs for this is the high degree of sterility of the stable wheat-rye hybrids. This unfavorable characteristic is caused

* Grain yield 23 quintals/ha.
** Grain yield 24.6 quintals/ha.

mainly by the differences in flowering and fertilization conditions. The wheat blooms in a closed manner: it is a self-fertilizer, whereas the rye blooms in an open manner: it is a foreign-fertilizer in addition to being self-incompatible. The hybrid becomes a self-fertilizer, same as wheat. This has unfavorable consequences with respect to the rye present in the hybrid (Fig. 1).

Fig. 1. Sterile wheat-rye hybrid.

(3) Most authors explained the high degree of sterility of Triticale in terms of the abnormal division in the meiosis, related mainly to the above-mentioned genetic and biological incompatibility (Kappus 1964; Krolow 1962; Nakajima 1963; Muentzig 1948; Schneider 1955; Vettel 1960a) (Fig. 2).

Fig. 2. The meiosis is irregular in the first generation of the wheat-rye hybrid

A more detailed review of all related problems is presented in another paper (Kiss 1966). Only a few special results obtained in crossing experiments shall be discussed here.

Wheat-rye crossings

Our main goal was to improve the unfavorable characteristics of Triticale. Since 1951 we were trying in Martonvasar and since 1957 in Kecskemet to produce the optimal genom stage of Triticale (Kiss and Redei 1953). In the course of the past 15 years, we were unable to obtain tetraploid Triticale(2n = 28) from diploid wheat and diploid rye (genom formula AASS). Insofar as we know, only Karapetjan (1964) has reported so far on amphidiploids with a chromosome number of 2n = 28 for wheat-rye hybrids.

Our first hexaploid Triticale (2n = 42; AABBSS), produced in 1951 by crossing Triticum turgidum buccale (AABB) with Secale cereale (SS) was no more yield-producing than Triticale that were known to have been produced abroad.

For crossings with Triticale we employed our own hexaploid and octoploid hybrids, and also Soviet, American, and -- for the last few years -- also 56-chromosome Swedish Triticale. For our Triticale crossing experiments we employed mainly the domestic hexaploids No 1 (2n = 42) and the octoploid Triticale. In addition to the crossing experiments, we tested X-ray induced mutations also. Although we have succeeded in the first stage of the Triticale study (1950-1960) in producing a very versatile hybrid material, nothing from it could be recommended for practical cultivation.

We wanted to attain a polyploid stage of the wheat-rye hybrids that resembles wheat. For this purpose, crossings of di-, tetra- and hexaploid wheat and diploid and tetraploid rye appeared suitable (Table 1,2,3). In our crossings with diploid wheat (2n = 14) we were unable to polyploidize the sterile hybrids (Table 1).

Surprisingly, we noted the lowest degree of crossability in the hybridization of wheat and rye with the same degree of polyploidy. It can be seen from Table 2 that the crossability of tetraploid wheat with rye is already more successful. In crossings of tetraploid wheat with rye, however, we always obtained completely shriveled, shrunken seeds without endosperm and a low degree of germinating ability (Fig. 3). Crossings of tetraploid wheat with tetraploid rye gave a better seed yield than with diploid rye. However, the germinating ability was still inadequate (Table 2).

The results of the crossing experiments with hexaploid wheat are presented in Table 3. The F_1 hybrids are without exception strongly or completely sterile. We treated the medium-yield Triticale with colchicin, or conducted crossings with available fertile Triticale over sterile hybrids. As a consequence of natural heat-shock effects, the octoploid Triticale 2 (B1-52) developed from a F_1 wheat/rye hybrid.

Kombination (1)	(1953–1960) Anzahl der gekreuzten Blüten 2)	Anzahl der erhaltenen Samen 3)	%	gekeimte Samen 4)
T. boeoticum 2x × *S.c.* 2x	2460	1	0,04	1
T. boeoticum 2x × *S.c.* 4x	1480	1	0,07	1
T. monococcum 2x × *S.c.* 2x	4998	3	0,06	1
T. monococcum 2x × *S.c.* 4x	3154	3	0,09	0
Zusammen: (5)				
2x × 2x	7458	4	0,05	2
2x × 4x	4634	4	0,05	1

Table 1. Crossability of diploid wheats with di- and tetraploid rye. 1) Combination; 2) 1953-1960; number of the crossed flowerings; 3) number of seeds obtained; 4) number of germinated seeds; 5) total.

Kombination (1)	(2) (1953–1960) Anzahl der gekreuzten Blüten	(3) Anzahl der erhaltenen Samen	%	Keimung (4) (5) Anzahl der Samen	Keimung (4) %
T. turgidum 4x × *S.c.* 2x	510	2	0,39	1	50,0
T. turgidum × *S.c.* 4x	450	13	2,89	3	23,07
T. durum 4x × *S.c.* 2x	5980	345	5,77	7	2,03
T. durum × *S.c.* 4x	4740	360	7,59	4	1,11
T. timopheevi 4x × *S.c.* 2x	4162	119	2,85	2	1,68
T. timopheevi × *S.c.* 4x	3112	111	3,56	0	0,0
T. carthlicum 4x × *S.c.* 2x	2170	82	3,77	2	2,44
T. carthlicum × *S.c.* 4x	2170	258	11,88	21	8,14
T. dicoccum 4x × *S.c.* 2x	4622	1	0,02	0	—
T. dicoccum × *S.c.* 4x	1990	0	0,0	—	—
T. m. autotetraploid × *S.c.* 2x	476	2	0,42	0	—
T. m. autotetraploid × *S.c.* 4x	120	1	0,83	1	100,0
Zusammen: (6) 4x × 2x	17920	551	3,07	12	2,17
4x × 4x	12582	743	5,90	29	3,90

Table 2. Crossability of tetraploid wheats with di- and tetraploid rye. 1) Combination; 2) 1953-1960; number of the crossed flowerings; 3) number of seeds obtained; 4) germination; 5) number of seeds; 6) total.

	(1953–1960)			Keimung (3)	
	(1) Anzahl der gekreuzten Blüten	(2) Anzahl der erhaltenen Samen	%	(4) Anzahl Samen	%
B 1201 — 6x × S.c. 2x	4037	2072	51,32	1045	50,43
B 1201 — × S.c. 4x	4588	1725	37,60	756	43,83
F 481 6x × S.c. 2x	4133	207	5,01	112	54,10
F 481 × S.c. 4x	5354	259	4,84	95	36,68
Aniversario 6x × S.c. 2x	2674	479	17,91	251	52,40
Aniversario × S.c. 4x	970	120	12,37	24	20,00
Freccia 6x × S.c. 2x	2090	210	10,05	135	64,28
Freccia × S.c. 4x	850	51	6,00	17	33,33
Thatcher 6x × S.c. 2x	2442	612	25,06	138	22,55
Thatcher × S.c. 4x	1642	615	37,45	135	21,95
6x × 2x zusammen: (5)	15376	3580	23,28	1681	46,95
6x × 4x zusammen:	13404	2670	19,92	1027	38,46

Table 3. Crossability of hexaploid wheats with di- and tetraploid rye. 1) Number of the crossed flowerings; 2) number of seeds obtained; 3) germination; 4) number of seeds; 5) total.

We investigated the main ears of our first hexaploid and octoploid Triticale, considering all flowerings. Unfortunately, the yields in this respect of our octoploid hybrids proved to be no better than the Triticale known from abroad. Since the number of ears per plant, as well as the number of seeds per plant, depends mainly on the agricultural technology, we gave preferred attention in our studies to the number of seeds per main ear and to the fertility of the ears.

It can be seen from Tables 4, 5, and 6 that Triticale No 1 and its wheat-parent have many flowerings, yet show a low number of seeds; thus, the fertility calculated on the basis of all flowerings is very low (31.0 - 37.4 and 33.4-36.6%). If we compare the yield-analytical data for the years 1961-1964 with those for the years 1951-1954, we can state that the hexaploid Triticale No 1 exhibited an increase of 19.2% in the number of seeds per ear during the 10 and 14 past years, but an increase in fertility of only 20.0%.If, however, we disregard the low seed yield for the first year in 1951, the increase is a mere 1.6 and 4.3%, respectively.

	Blüten 1)	Samen 2)	Fertilität % 3)
1951	95,0	15,0	15,8
1952	107,1	41,2	38,5
1953	101,2	37,1	37,6
1954	99,0	31,5	31,8
zusamm(4):	402,3	124,8	
X	100,57	31,20	31,0
1961	90,1	33,5	37,2
1962	107,0	38,4	35,9
1963	92,4	39,1	42,5
1964	110,5	37,8	34,2
zusamm(4):	400,0	148,8	
X	100,0	37,20	37,4
Zuwachs % in den Jahren (5)			
1961–64	– 0,57	19,2	20,6

Table 4. Seed yield and fertility of the main ears of the hexaploid Triticale No 1 in 1951-54 and 1961-64. 1) Flowerings; 2) seeds; 3) fertility %; 4) total; 5) increase in % during the years.

	Blüten 1)	Samen 2)	Fertilität % 3)
1951	82,2	57,1	69,5
1952	85,1	60,0	70,5
1953	106,0	72,0	67,9
1954	65,2	53,5	82,0
zusammen: (4)	338,5	242,6	
X	84,62	60,65	71,7
1961	65,1	51,8	79,6
1962	71,4	57,9	81,1
1963	70,3	57,9	82,4
1964	67,8	50,0	73,7
zusammen: (4)	274,6	217,6	
X	68,65	54,40	79,2
Zuwachs % in den Jahren (5)			
1961–64	–18,9	–10,3	10,5

Table 5. Seed yield and fertility of the main ears of Secale cereale used for the crossings during 1961-1964. 1) Flowerings; 2) seeds; 3) fertility %; 4) total; 5) increase in % during the years.

	Blüten 1)	Samen 2)	Fertilität % 3)
1951	104,2	32,1	30,8
1952	110,0	35,0	31,8
1953	125,9	47,0	37,3
1954	98,1	32,2	32,8
zusammen:	438,2	146,3	—
X (4)	109.55	36,57	33.4
1961	111,0	39,7	35,8
1962	114,8	45,5	39,6
1963	93,3	33,4	35,8
1964	102,0	35,6	34,9
zusammen:	421,1	154,2	—
X (4)	105,28	38,55	36,6
Zuwachs % in den Jahren (5)			
1961—64	—3,90	5,40	9,58

Table 6. Seed yield and fertility of the main ears of Triticum turgidum buccale used for the crossings during 1951-54 and 1961-64. 1) Flowerings; 2) seeds; 3) fertility %; 4) total; 5) increase in % during the years.

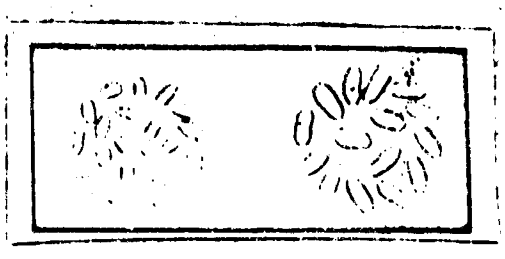

Fig. 3. Shriveled seeds from the crossing of tetraploid wheat and rye (left) as compared with the crossing of hexaploid wheat and rye (right)

Although we always employed the progeny of the highest-yield individual for the strain tests, the yield of our first hexaploid Triticale did not increase during the past 14 years. This hybrid is especially strong; however, it has large seeds and ears (Fig. 4) -- yet the seeds are shriveled and wrinkled.

Since neither the octoploid hybrids nor the *Triticale* from abroad produced noteworthy results, we tried to obtain new combinations and, through X-ray effect, better mutations, by means of *Triticale* crossings. We obtained valuable lines only by crossing various polyploidy stages. We shall report about this below.

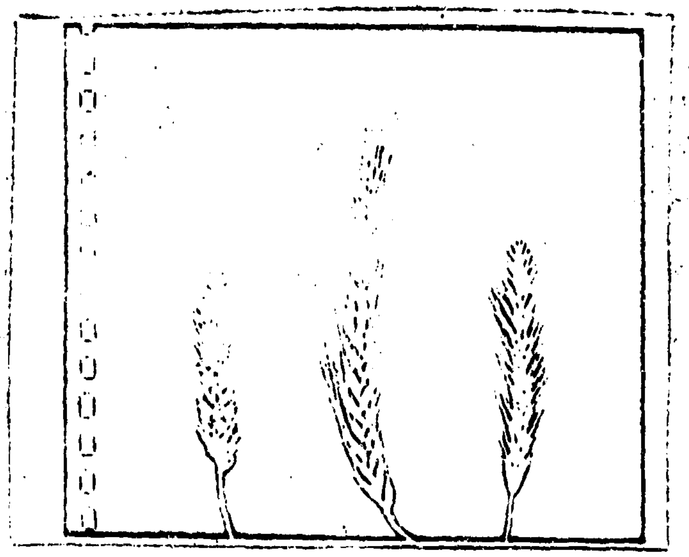

Fig. 4. The long ear of *Triticale* No 1 (center), compared to the ears of its parents.

Triticale crossings

Although none of the *Triticale* to-date is suitable for practical cultivation, there are among them some types that excel in terms of strong blade, long ear, early maturity, and resistance to disease and cold temperatures. These properties induced us to attempt to combine them with the aid of crossings.

The hexaploid *Triticale turgidocereale* excel in terms of vigorous growth, long ears, large seeds, and resistance to rust (stem and leaf rust) and flour blight. As a rule, the octoploid *Triticale* are shorter and have smaller ears. Most are also prone to diseases. Surprisingly, in the crossing experiments the F_1 generation had no higher fertility than the better parent, although it exhibited both in terms of growth and of ear length a mild heterosis effect. The seed yield of the octoploid hybrids

was surprisingly low also (Table 7). Whereas the hybrids from the wheat/rye crossing were sterile, the octoploid Triticale hybrids showed a low degree of fertility (Table 8).

Kombination (1)	Anzahl der gekreuzten Blüten (2)	Anzahl der erhaltenen (3)		Anzahl der gekeimten (4)	
		Samen	%	Samen	%
B. Tc. × Tc. Rimpau	280	10	3,57	5	50
F. Tc. × Tc. Rimpau	200	18	9,0	12	66,6
B. Tc. × Tc. Meister	224	9	4,02	3	33,3
F. Tc. × Tc. Meister	200	22	11,0	16	72,7
B. Tc. × Tc. Taylor	224	50	22,32	46	92,0
B. Tc. × Tc. Taylor	200	41	20,50	34	82,9
B. Tc. × AD 20/1	230	11	4,78	5	45,5
F. Tc. × AD 20/1	200	36	18,0	29	80,5

B. Tc. = B 1201 × *S. cereale*; Amphiploid AD 20/1 = *Triticale* Pissarev; F. Tc. = F 481 × *S. cereale*.

Table 7. Seed yield of the octoploid hybrids. 1) Combination; 2) number of crossed flowerings; 3) number of seeds obtained; 4) number of germinated seeds.

The octoploid Triticale F_1 hybrids surpassed the better parent in terms of growth length by 1-8%, and in terms of ear length by 2-21%. Surprisingly, however, the seed yield of the main ears and the fertility of the small ears was inferior than that of the better parent (number of seeds per ear: 52-99%: number of grains per small ear: 54 and 98%, respectively). We have performed a large number of additional crossings; however, in most cases only the throttled seeds could be identified in the individual plant. In the first instance, we concluded from these experiments that the low degree of fertility of the octoploid Triticale cannot be attributed to the inbreeding of the rye.

Our hybrids are of a large variety of origins, with both the wheat and the rye component exhibiting considerable differences. In the main ears, there should have been evident a heterosis effect. Same as in the seed yield, where no improvement could be seen, there was no change in the fact that the seeds remained shriveled and wrinkled also. Since we did not succeed in developing higher-yield progeny in subsequent generations, we ceased to experiment with octoploids.

Kombination (1)	Pflanzen- (2)	(3)	(4)	(5)	(6)
B. Tc.	20	155,0 ± 0,48	14,0 ± 0,20	20,1 ± 0,71	0,69 ± 0,21
F. Tc.	20	157,5 ± 0,71	13,6 ± 0,42	17,7 ± 1,26	0,60 ± 0,14
Tc. R.	15	135,9 ± 0,28	12,5 ± 0,26	8,2 ± 0,26	0,46 ± 0,15
Tc. M.	22	139,8 ± 0,19	11,7 ± 0,16	20,2 ± 0,20	0,93 ± 0,11
Tc. T.	14	136,1 ± 0,97	13,1 ± 0,12	21,6 ± 0,20	1,03 ± 0,13
AD 20/1	20	127,7 ± 0,22	15,3 ± 0,24	33,8 ± 0,38	1,31 ± 0,16
B. Tc. × Tc. R.	5	168,0 ± 0,98	16,1 ± 0,75	15,2 ± 0,90	0,54 ± 0,31
F. Tc. × Tc. R.	10	169,5 ± 0,65	15,7 ± 0,61	11,5 ± 0,75	0,48 ± 0,16
B. Tc. × Tc. M.	3	161,0 ± 1,25	15,3 ± 0,99	23,2 ± 1,30	0,97 ± 0,33
F. Tc. × Tc. M.	14	159,6 ± 0,70	14,8 ± 0,60	19,4 ± 0,65	0,82 ± 0,20
B. Tc. × Tc. T.	38	158,2 ± 0,62	15,2 ± 0,42	24,0 ± 0,42	1,00 ± 0,16
F. Tc. × Tc. T.	30	158,5 ± 0,65	15,0 ± 0,47	21,5 ± 0,51	0,98 ± 0,17
B. Tc. × AD 20/1	5	167,5 ± 0,99	16,8 ± 0,92	28,6 ± 0,96	1,02 ± 0,38
F. Tc. × AD 20/1	24	169,7 ± 1,17	16,5 ± 0,51	25,1 ± 0,60	0,90 ± 0,21

* B. Tc. = B 1201 × *S. cereale*; F. Tc. = Tc. 481 × *S. cereale*; Tc. R. = Tc. Rimpau; Tc. M. = Tc. Meister; Tc. T. = Tc. Taylor.

Table 8. Growth, ear length, and seed yield of the ears of octoploid Triticale. 1) Combination; 2) number of plants; 3) growth (cm); 4) ear length (cm); 5) number of seeds per ear; 6) number of seeds per small ear.

The behavior of the subsequent generation from crossings between Triticale of different degrees of polyploidy was surprising, however. In Table 9, we have plotted the crossability of Triticale of various degrees of polyploidy and the germination of the F_1 seeds. We started with the tests during 1954, and obtained the first F_1 generation in 1955. The regularity noted in the crossings was surprising. In the 6x times 8x direction we obtained a seed yield of 0.62, in the 8x times 6x direction we obtained one of 12.22%.

Since the relation is reverse in wheat of various degrees of polyploidy, we repeated the experiment in the 1958-1962 period. We obtained from the crossings of 14,620 flowerings, a grain yield of 1.78% in the 6x times 8x direction, a reciprocal of 16.12% (Fig. 5). Sulyndin and Naumova (1965) reported recently about similar crossings. They found in the 6x times 8x direction a 4.0%, and reciprocally (8x times 6x) a 13.4% seed yield. (Their hexaploid Triticale originated from the crossing T durum x S. cereale; ours, from the crossing T turgidum buccale x S. cereale.)

The seeds originating from these crossings were shriveled and wrinkled the same way as those from the parents. To determine the hybrid character of these crossings, we employed a number of morphological properties (Table 10).

Kombination (1) (Genomstufe: 6x = 42; 8x = 56)		Anzahl der gekreuzten Blüten (2)	Anzahl der erhaltenen (3) Samen	%	Anzahl der gekeimten (4) Samen	%	F1-Pflanzen (5)
Tc. Nr. 1 × Tc. Meister	6×8	660	2	0,30	1	50	0
Tc. Meister × Tc. Nr. 1	8×6	780	143	18,33	97	67,83	37
Tc. Nr. 1 × Tc. Taylor	6×8	360	2	0,55	1	50,0	0
Tc. Taylor × Tc. Nr. 1	8×6	390	74	18,97	42	56,75	26
Tc. Nr. 1 × Tc. Rimpau	6×8	330	3	0,91	2	66,66	2
Tc. Rimpau × Tc. Nr. 1	8×6	270	12	4,44	5	41,60	5
Tc. Nr. 1 × Tc. Hadmersleben	6×8	150	0	0,0	—	—	—
Tc. Hadmersleben × Tc. Nr. 1	8×6	150	4	2,67	1	25,0	—
Tc. Nr. 1 × Tc. Spindelbrüchig	6×8	120	1	0,83	1	100,0	1
Tc. Spindelbrüchig × Tc. Nr. 1	8×6	120	5	4,17	5	100,0	5
Tc. Nr. 1 × F. Tc.	6×8	160	3	1,87	2	66,6	2
F. Tc. × Tc. Nr. 1	8×6	312	9	2,88	4	44,49	4
2 n 42 × 56 (6x × 8x)		1780	11	0,62	7	63,60	5
2 n 56 × 42 (8x × 6x)		2022	247	12,22	154	62,35	78

Table 9. Crossability of hexaploid/octoploid Triticale in 1954. 1) Combination (genom state: 6x = 42; 8x = 56); 2) number of crossed flowerings; 3) number of seeds obtained; 4) number of germinated seeds; 5) F_1 plants.

Fig. 6. Crossing of Tc. Rimpau (2n = 56) with Triticale No 1 (2n = 42), with the ear of the F_1 hybrid in center.

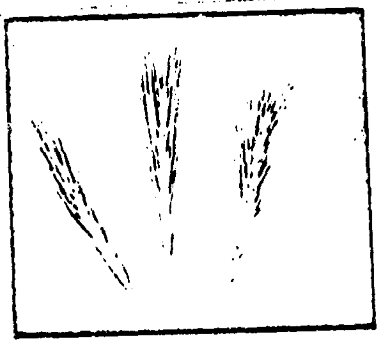

Fig. 7. Crossing of Tc Meister (2n = 56) with Triticale No 1 (2n - 42), with the ear of the F_1 hybrid in center.

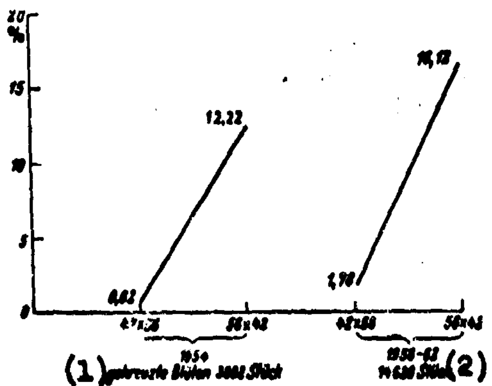

Fig. 5. Crossability of hexaploid and octoploid Triticale. 1) 3802 crossed flowerings; 2) 14,620 individual crossings.

Kombination Elter — F_1 (1)	(2) Halmlänge (cm)	(3) Ährenlänge (cm)	Behaarung des Halmes unterhalb der Ähre (4)	Farbe der Ähren (5)	Farbe der Auricula (6)	Anzahl der Körner je Pflanze (7)	Anzahl der Körner je Ähre (8)
Triticale Nr. 1.	178,9	14,9	bg	ag	w	188,6	31,5
Tc. Meister × Triticale Nr. 1.	171,0	16,0	bg	ag	hr	1,08	0,12
Tc. Taylor × Tc. Nr. 1.	168,0	15,2	bg	ag	w	1,19	0,11
Tc. Rimpau × Tc. Nr. 1.	175,0	18,6	bg	ag	w	0,20	0,03
Tc. Spindelbrüchig × Tc. Nr. 1.	164,0	18,5	bg	ag	w	0,80	0,11
F. Tc. × Tc. Nr. 1.	178,0	15,4	bg	ag	r	0,20	0,02
Tc. Meister	139,0	11,7	bg	ag	hr	169,1	20,2
Tc. Taylor	136,0	13,1	bg	ag	w	205,6	21,6
Tc. Rimpau	136,0	13,3	gl	hg	w	74,4	8,2
Tc. Spindelbrüchig	134,0	12,9	gl	g	w	101,5	7,7
F. Triticale	154,0	13,7	bg	ag	r	201,7	23,9

Abkürzungen: bg = begrannt; gl = glatt; ag = aschgrün; w = weiß; hr = hellrosa; hg = hellgrün; r = rot; g = grün.

Table 10. Morphological characteristics and fertility of the Triticale F_1 generation and of the parents. 1) Combination; Parent - F_1; 2) Stalk length (cm); 3) ear length (cm); 4) hairiness of the stalk beneath the ear; 5) color of the ear; 6) color of the auricula; 7) number of seeds per plant; 8) number of seeds per ear. Abbreviations: bg = whiskery; gl = smooth; ag = ash grey; w = white; hr = light pink; hg = light green; r = red; g = green.

In the case of the crossing with Triticale Rimpau and Triticale Spindelbrüchig, the hybrid character could be concluded already in the ear shifting, since the hairiness of the stalk beneath the ear of Triticale No 1 was dominant. In the maturity period, the ash-green color dominated over the light-green or medium-green color for the ear in both of the above-mentioned Triticale (Figs. 6 and 7).

The red color of the auricula of Triticale Fleischmann also dominated over the white color. The stalk length corresponded to that of the taller parent. Later we found in some crossings a small heterosis effect. Insofar as the length of the ears is concerned, the heptaploid hybrids showed without exception a considerable heterosis effect (compared to their parents that had longer ears).

The inheritance of ear length was investigated on the basis of

the main ears in the combination of the short-ear Triticale Meister with the long-ear Triticale No 1 (Table 11). In the F_2 generation, 148 main ears were examined. They all showed transitions in ear density between compactoids and speltoid configurations.

Eltern, F_1- und F_2-Bastarde (1)	Ährenlänge cm (2)										n	$\bar{x} \pm s$
	4–6	6–8	8–10	10–12	12–14	14–16	16–18	18–20	20–22	22–24		
Triticale Nr. 1.	—	—	1	6	13	29	6	5	—	—	60	14,60 ± 2,17
Tc. Meister × Tc. Nr. 1. F_1	—	—	—	—	6	11	9	7	4	—	37	16,56 ± 2,50
F_2	4	18	16	11	12	20	15	29	17	6	148	16,64 ± 5,12
Tc. Meister	—	9	23	24	4	—	—	—	—	—	60	9,76 ± 1,65

Table 11. Inheritance of ear length in hexaploid-octoploid Triticale hybrids in the F_1 and F_2 generation. 1) Parents, F_1 and F_2 hybrids; 2) ear length in cm.

The seed yield of the first generation from crossings between Triticale of various degrees of polyploidy was very low. There were 0.2-1.2 (one on the average) grains per plant, corresponding to a value of 0.02-0.12 per ear. We obtained a total of 77 seeds from F_1 hybrid 77; while these were quite shriveled, they germinated well (87%). Although the F_1 generations of the Triticale crossings of the octoploid x octoploid type showed a higher degree of fertility than did the above crossings, it was still possible to select in crossings and back-crossings of hexaploid x octoploid Triticale individuals with average seed yield in a surprisingly rapid manner, as early as in the second generation. In the F_3 and F_4 generations, some lines even surpassed the performance of the better parent.

The hexaploid Triticale No 30 was selected from the third generation of such a crossing during the year of 1960. In the F_1 and F_2 generation, it still exhibited a high degree of sterility. In F_3 it already had individuals with a seed yield close to that of rye. Triticale No 30 had 42 chromosomes, same as did Triticale No 1 prepared from Tr. turgidum; however, it retained the red color of the auricula of the hexaploid wheat, F 481. The red auricula of the hexaploid Triticale No 30 is regarded as a marker originating from wheat F 481, that is readily identifiable in the progeny and may, as a matter of fact, be transformed from hexaploid wheat into hexaploid Triticale.

We conducted larger-scale planting tests with this Triticale No 30 during 1964 (it is now in Generation F_8). Since 1961, however, we conducted productivity tests in regular cultivation (Fig. 8). Since, in experiments conducted so far, the Triticale did not reach the productivity of the H-rye of Kecskemet in sandy soil, we give here only the seed yield (Table 12).

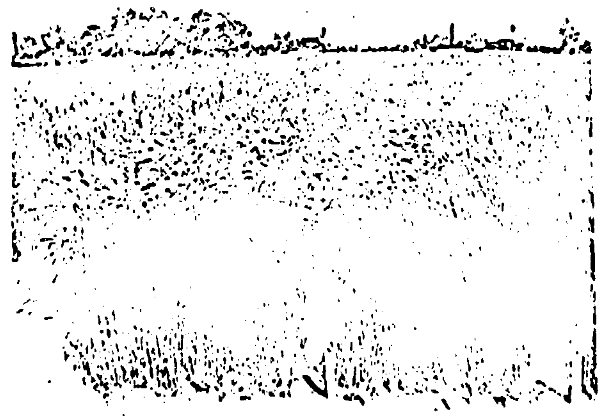

Fig. 8. Regular cultivation test of Triticale, 1961.

	1961	1962	1963	$\bar{X}$
	seed yield, dt/ha			
Kecskemet H-rye	32.60	27.98	26.83	29.14
Hexaploid Triticale No 30	24.68	24.16	21.72	23.51
SD 5%	2.35	1.53	2.09	--
Difference in favor of K. H-rye	7.92	3.82	5.11	5.63

Table 12. Regular cultivation tests with the hexaploid Triticale No 30 during 1961-1963. Plot size: 28.78 sq m; 6 repetitions.

We stopped these tests subsequently since the results of the first three years showed that a type with at least 20% higher yield had to be obtained to compete with rye. The Triticale No 30 was multiplied in 1964 at the culture areas of LPG Aranykalasz in Kecskemet over 4.5 cadastral acres, i.e., 2.59 hectares (1 kj = 0.5755 ha). The total harvest was 54.32 dt, corresponding to a seed yield of 21.1 dt/ha. The tetra rye gave on other areas of the institution a seed yield of 15.4 dt/ha; the winter rye 'Beta,' one of 14.3 dt/ha. The cultivation area of the tetra rye, it should be noted, was about 17 ha, and that of the winter rye, about 35 ha.

In 1965, Triticale No 30 was grown over an area of about 17 ha in LPG Aranykalasz. The yield was 23.0 dt/ha (rye, 16.9; winter barley, 28.2 dt/ha). During the fall of 1965, 300 Kj (172.5 ha) were planted of this Triticale.

The experts expect great results from this new plant on sandy soils, since it resists aridity well and tolerates sandy soil as well as does rye. It has an almost twice as high protein content as rye and winter barley. Thus, this plant has significance with respect to protein production also. For this reason, both this secondary hexaploid Triticale and its improved lines will play an important role in the growing of protein- and fattening-fodder.

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